The official voice of the Air Force Research Laboratory
news@afrl
Features
January 2002

Breakthrough benefits aging aircraft fleet

by Gary Cunningham, Materials and Manufacturing Directorate

WRIGHT-PATTERSON AFB, Ohio— Increasing requirements placed on the Air Force's aging aircraft fleet created a need for innovative technologies to reduce escalating costs and improve the fleet's sustainability.

A group led by the Manufacturing Technology (ManTech) Division of the Air Force Research Laboratory Materials and Manufacturing Directorate, has made a quantum leap in meeting these goals. Together with researchers at InfoScribe Technologies, Ltd. (ISTL), and Veridian Engineering, the group developed the first integrated data management system for the Eddy Current Inspection System (ECIS). ECIS is a state of the art inspection station for many of the Air Force's gas turbine engine disks, headquartered at Tinker AFB, Okla.

Within the current fleet, sustainment of gas turbine engines cost the Department of Defense $2.2 billion in fiscal year 2000, according to information released by the Government Accounting Office. This represented 63 percent of the Air Force's gas turbine propulsion budget.

When implemented Air Force-wide, the crucial new data mined will improve safety thresholds, support initiatives to reduce disk replacement costs by 50 percent and increase depot throughput while reducing the overhaul cost per component. This invaluable information will give aircraft engine maintenance officials the ability to save millions of dollars in parts acquisition through enhanced management of turbine engine disk life cycles.

Turbine engine disks were traditionally replaced upon reaching a pre-determined number of operating hours. This practive proved expensive, as disks are made of exotic alloys that push their price tag from $25,000 to upwards of hundreds of thousands of dollars each. There has been a long-standing perception that the gathering and intelligent processing of more accurate information would add precision to the calculation of engine disk life cycles, which would substantially increase current life limitations and overall safety, while reducting costs.

Manufacturing processes improved the quality and durability of aircraft parts like engine disks, but the retirement timeframe did not change because computer technology wasn't available to provide sufficient analysis of the disk's condition. It was believed that many disks had one or more cycles remaining beyond their established timeframe.

The Retirement For Cause (RFC) program was implemented to focus on finding ways to improve inspection methods, and to locate flaws or cracks in components, thus reducing the cost to maintain the readiness of the air fleet. Early inspections, using hand-held probes, collected information to confirm that a large number of disks were being retired prematurely, but not enough to change the policy of life cycle retirement.

In the mid-1980s, Veridian Engineering led a consortium that married state-of-the-art nondestructive inspection with fracture mechanics modeling to develop an automated method of detecting cracks or flaws in F-100 and F-110 engine parts. Their efforts produced the ECIS Station.

The station is a large manipulator consisting of an electronic arm atop a large granite block to give it stability. An engine disk is placed on a turntable that rotates as needed. The manipulator arm, holding a probe, maneuvers over, around, and through the various surfaces of a disk being inspected, collecting an assortment of status readings. Different geometric features on a disk require different probes. For example, one type of probe is used to inspect bolt-holes, while another probe is used to inspect turbine blade slots.

The accuracy and throughput provided by the ECIS proved to be a huge step forward. It provided Air Force maintenance officials with a clearer "go/no go" status of each disk inspected. Since the RFC program was initiated, and the first of what is now 26 ECIS Stations went into operation at Tinker AFB, Okla., more than $850 million in cost avoidance has been realized.

However, technology was still a barrier in reaping the full benefits of the ECIS. Computer hard drives of

Continued on page 2

Continued from page 1

the day were extremely limited in storage capacity. They were only capable of storing a single disk's inspection analysis until a final report was generated. The stored data then had to be deleted from the hard drive to make room for the analysis from the next inspected disk. Purchasing additional hard drives was cost prohibitive.

In 1995-96, ISTL developed a data collection software application under a Small Business Innovative Research (SBIR) project for a different government program. This application was capable of collecting and organizing hundreds of unique parameters simultaneously. Engineers from ManTech's Materials Process Design Branch saw the potential of adapting ISTL's application for the ECIS Station. ManTech succeeded in having the companies join forces under a SBIR enhancement.

ISTL modified their software to enable communication with an ECIS, and vice versa. ECIS control software was modified to pull data out at relevant points in time during an engine disk inspection, and send it to the ISTL computer. The Veridian-built interface has allowed ISTL to archive the data in their system, which is predicted to reach a storage capacity of one terabyte (1,000 gigabytes) per year.

Working together, ISTL and Veridian installed the prototype system, using one of the stations at Tinker AFB, to collect and manage the inspection data. In a five-month period the prototype collected more than five gigabytes of data. An updated version was installed, mining more than twice the amount of the first in a similar five-month time frame. This wealth of raw data paints an operational status picture of the surface of each disk inspected. With the memory storage problem solved, the usage measurements of each disk can be charted for comparison during subsequent inspections.

The future for this program promises even greater benefits. Representatives from ISTL and Veridian , along with ManTech, are working on a data mining application to reuse and reanalyze previously archived data to perform "simulated re-inspections" on engine disks. The rationale is simple. Inspections are repeated by recalling archived data from InfoScribe. By interactively modifying the standard inspection parameters, disks can be inspected to smaller crack detection limits. If flaw indications are found, then all similar parts can be re-inspected without recalling engines from service, providing a powerful tool for fleet managers to assess risk.

This capability will tell engine life management personnel if there is a widespread problem, or just a one-time occurrence. This can mean the difference between grounding the entire fleet or not.

The underlying area this research will assist in is the determination of what is causing engine disk flaws to grow, how many and how fast. By combining the information collected on the ECIS with maintenance and flight data it will be possible to correlate the operational conditions to flaw growth. This correlation is critical in determining the readiness of the fleet and maintenance cycles required based on flight profile information.

This data can also be used to see if any other trends were present that might have led to a part failing. For instance, was this part located in a very cold, humid climate, and recently transferred to a very dry, hot climate?

The amount of new data being collected has provided a quantum leap forward by improving flight safety, saving millions of dollars in parts acquisition, increasing fleet readiness, and providing the capability to expand the system's use to benefit other Air Force assets. **@**